



**US Department of Energy**  
**Distributed Energy Road Show**  
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# Forward-Looking Statements



This presentation contains forward-looking statements that are made pursuant to the Safe Harbor provisions of the Private Securities Litigation Reform Act of 1995. Forward-looking statements involve risks, uncertainties and assumptions as described from time to time in registration statements, annual reports, and other periodic reports and filings of the Company filed with the Securities and Exchange Commission. All statements, other than statements of historical facts, which address the Company's expectations of sources of capital or which express the Company's expectation for the future with respect to financial performance or operating strategies, can be identified as forward-looking statements. As a result, there can be no assurance that the Company's future results will not be materially different from those described herein as "believed", "anticipated", "estimated" or "expected", which reflect the current views of the Company with respect to future events. We caution viewers that these forward-looking statements speak only as of the date hereof. The Company hereby expressly disclaims any obligation or undertaking to release publicly any updates or revisions to any such statements to reflect any change in the Company's expectations or any change in the events, conditions or circumstances on which such statement is based.

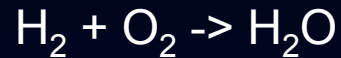
# Outline



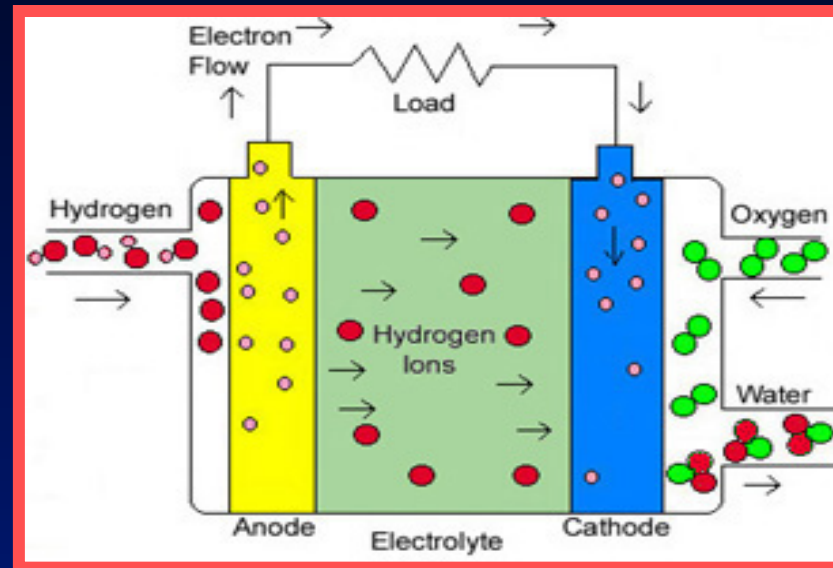
- **What is a Fuel Cell?**
  - Types of Fuel Cells
- **What is a Fuel Cell System?**
  - Fuel Processor
  - Balance of Plant
  - Inverter
- **Technology Adoption**
- **Codes and Standards**
  - Product Standards
  - Installation Standards
  - Interconnect Standards
  - Challenges
- **System Interfaces**
- **Questions**



# Fuel Cell - Fundamentals



A fuel cell is a device that generates electricity by electrochemically reacting hydrogen and air.



Every fuel cell has

One positive electrode - cathode

One negative electrode - anode

An electrolyte - carries charged particles

A catalyst - speeds up the reactions to generate electricity

# Fuel Cell Operating Comparisons



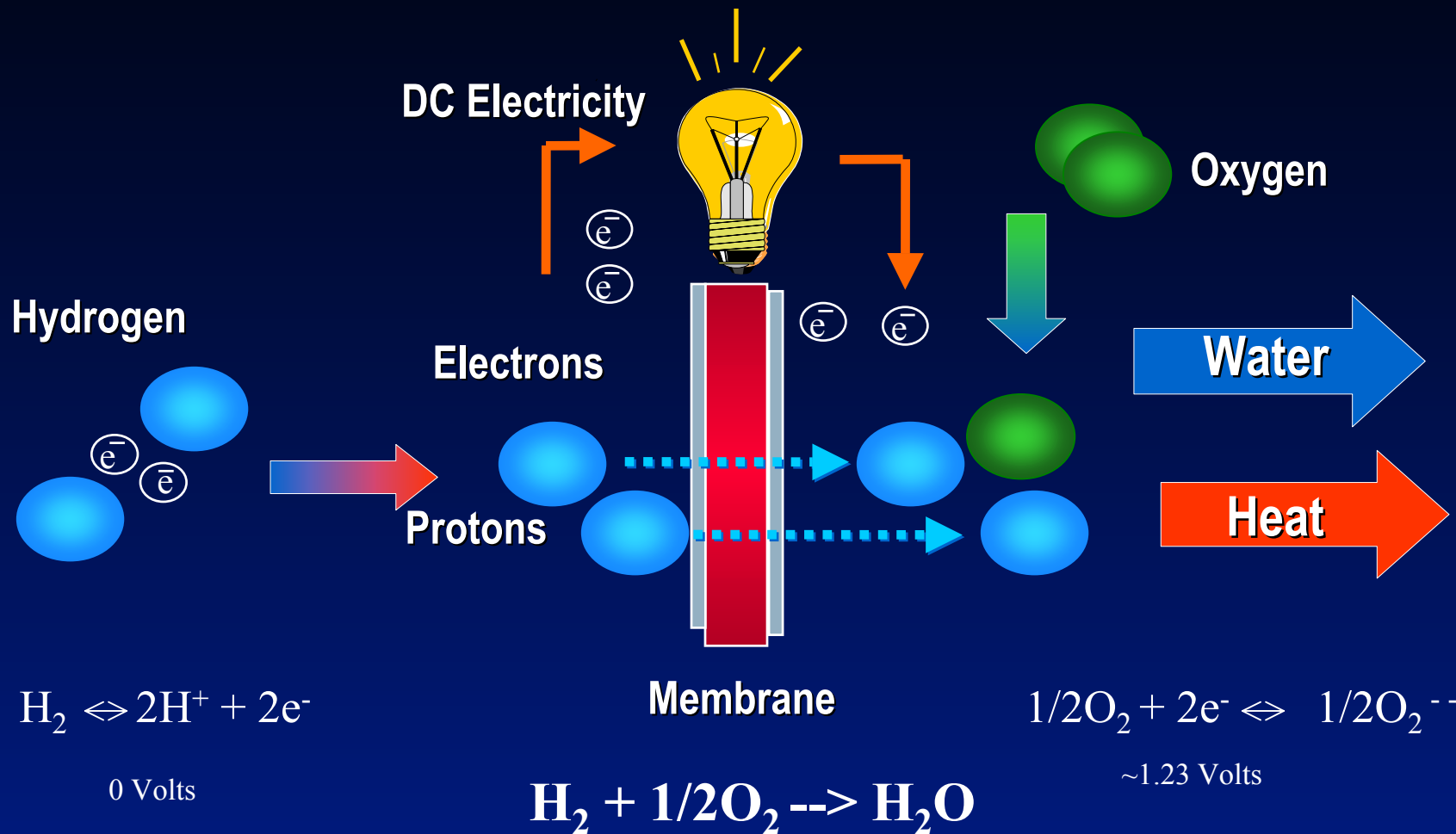
Fuel Cell Type	Electrolyte	Ions	Temperature (°C)	Cell Voltage (V)	Size (largest) (kW)
<b>Alkaline</b>	Potassium Hydroxide	OH <sup>-</sup>	80	0.6 - 0.8	100
<b>PAFC</b>	Phosphoric Acid	H <sup>+</sup>	200	0.6 - 0.8	670
<b>MCFC</b>	Molten Carbonate	CO <sub>3</sub> <sup>=</sup>	550 - 650	0.7 - 0.85	250
<b>SOFC</b>	Solid Doped Zn-Oxide	O <sup>=</sup>	850 - 1000	0.6 - 0.75	100
<b>PEMFC</b>	Solid Polymer	H <sup>+</sup>	100	0.6 - 0.8	250

# Fuel Cell Operating Comparisons



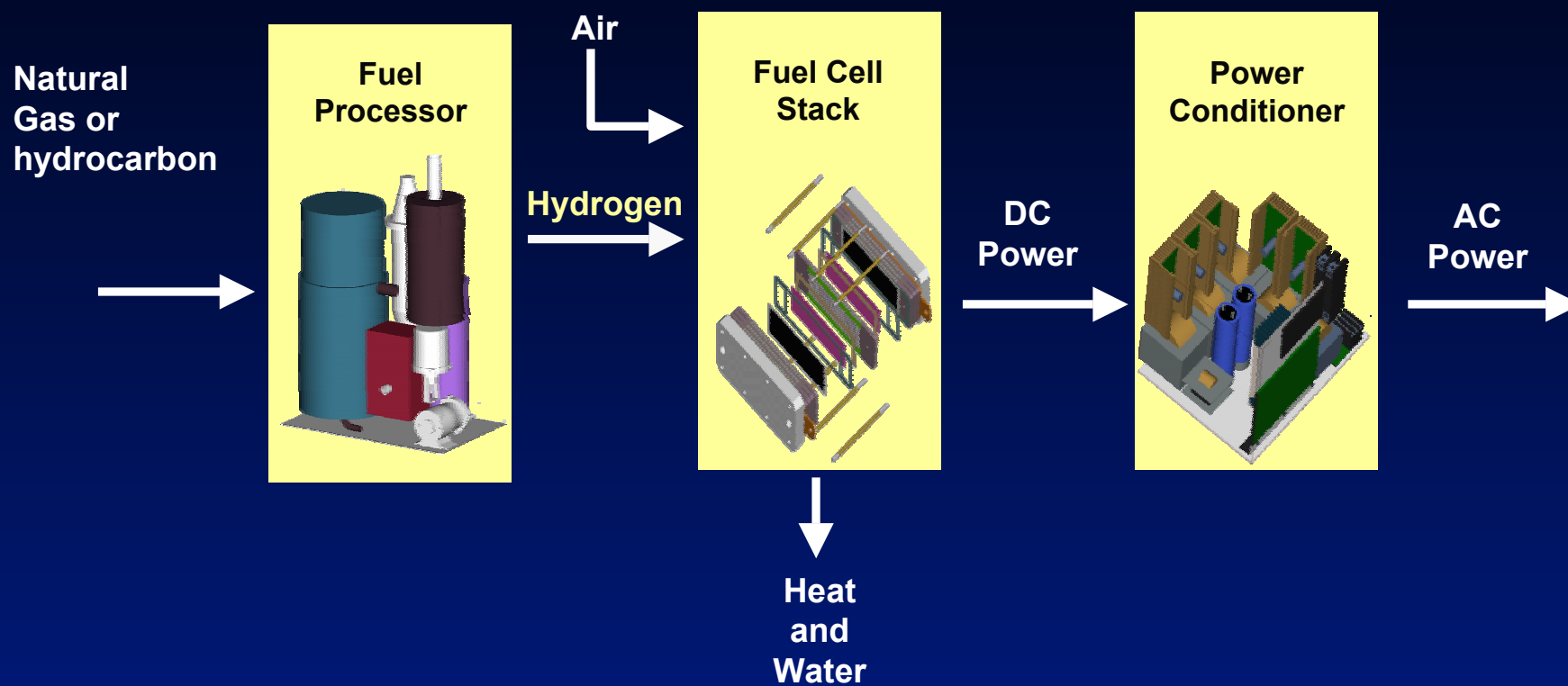
Fuel Cell Type	Current Density (mA/cm <sup>2</sup> )	System Efficiency	Fuel Proc. Complexity	Stack Power Density	Transient Capability
Alkaline	60 - 120	35 - 50	Medium	Medium	High
PAFC	100 - 400	35 - 45	Medium	Medium	Medium
MCFC	100 - 200	45 - 55	Low	Low	Low
SOFC	100 - 300	45 - 50	Low	Medium	Low
PEMFC	400 - 900	32 - 40	High	High	High

# Fuel Cell Process



*Approx. 1 volt or less/cell, therefore add cells together*

# System Components





# Integrated System



Fuel  
Air  
Water

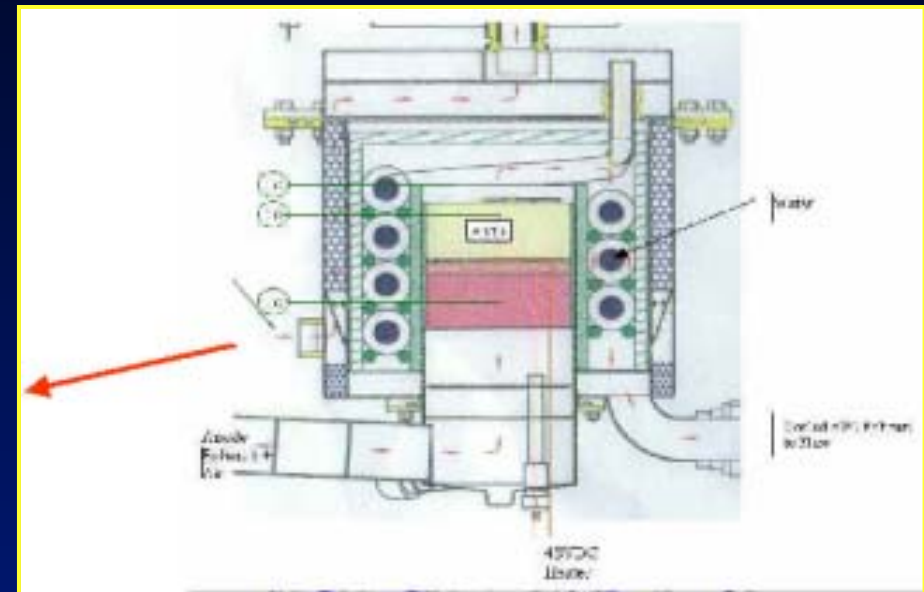


AC  
Power  
Heat

Fuel  
Processor

Power  
Generation

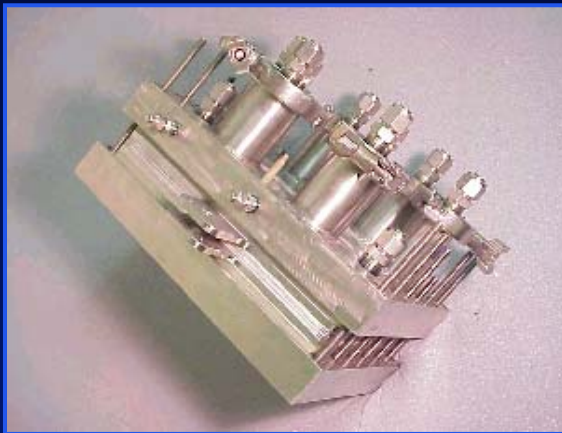
Inverter



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## Power Generation

**Power Generation Module** - uses hydrogen in reformat to produce electricity (DC voltage)



# Power Generation & Balance of Plant



- Fuel & Air Delivery
- Cooling
- Waste Heat Capture
- Integrated Controls
  - Fuel Processor
  - Stack/Balance of Plant
  - Inverter/Grid



## Inverter

- Convert Stack DC power or Battery DC power to AC power
- Provide Auxiliary power
- Provide isolation between the stack and the AC connection
- Provide control system all electrical statistics including stack voltage and current
- Provide Anti-Islanding capability

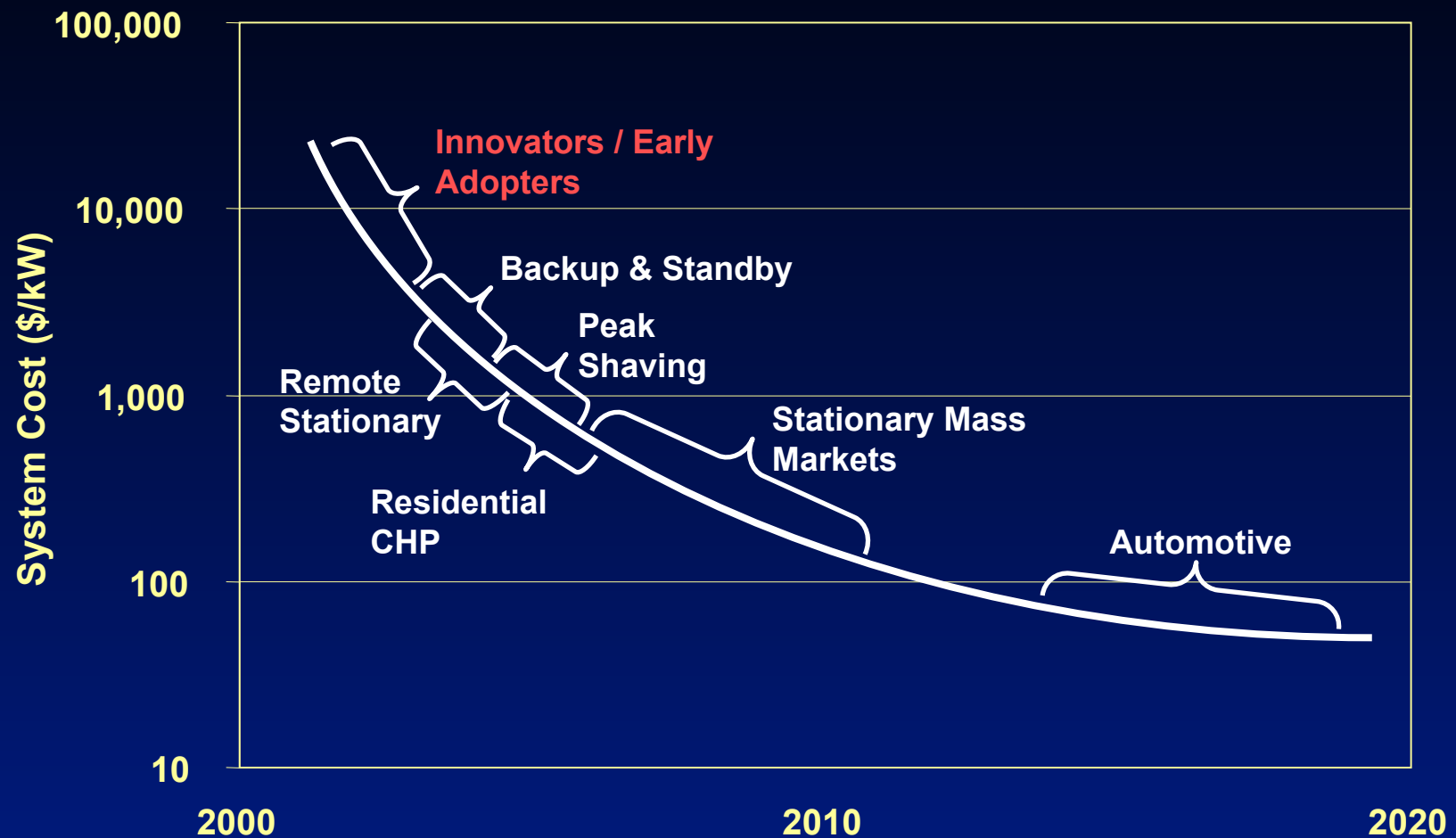


# PEM Technical Challenges

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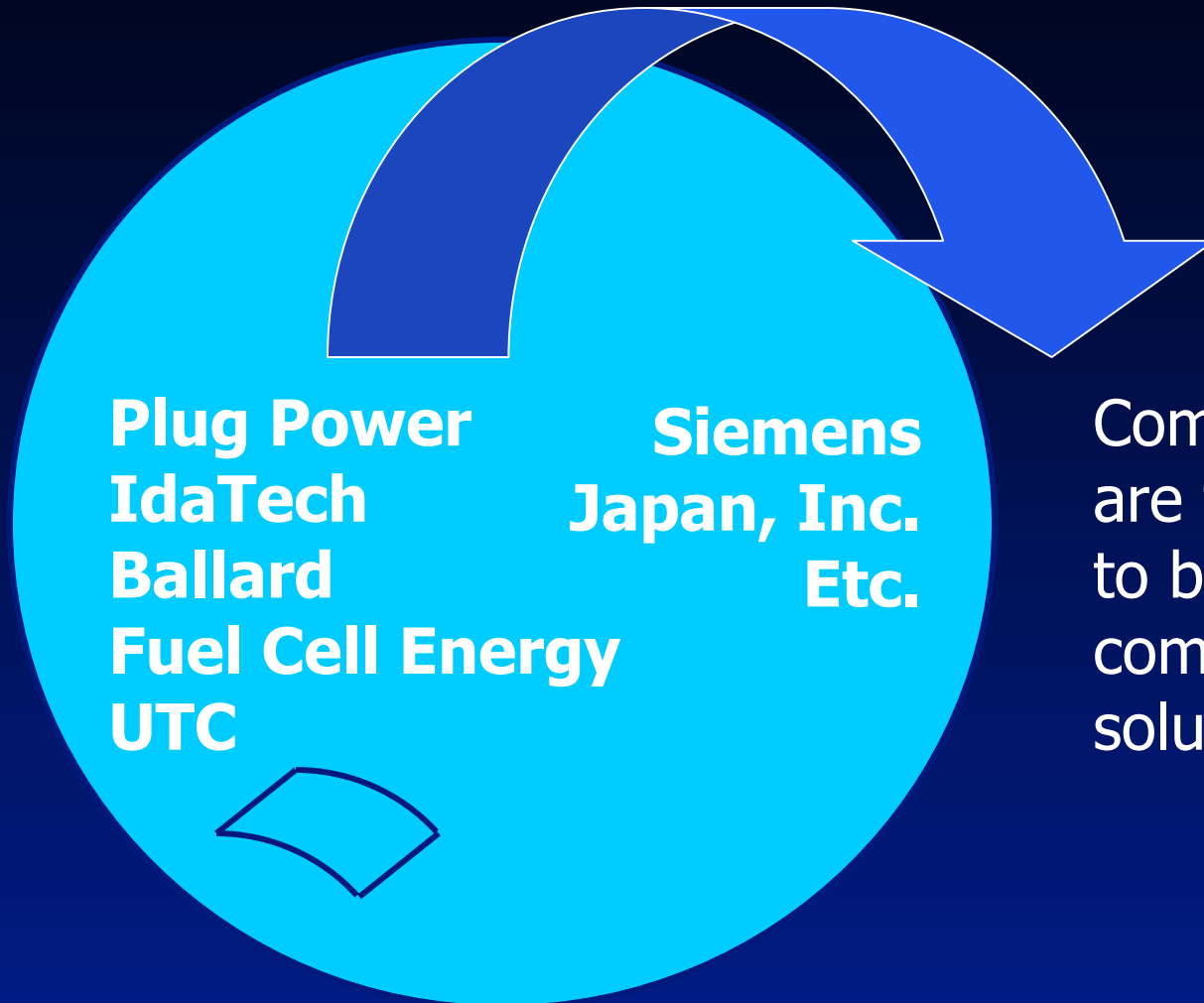
- Fuel Processor
  - Alternate Fuels
  - Energy Storage, Load Following
- Stack
  - Longevity
- Controls
  - Load Following
  - Communications
- Cost

# The Future - Industry Cost Curve



## The Industry

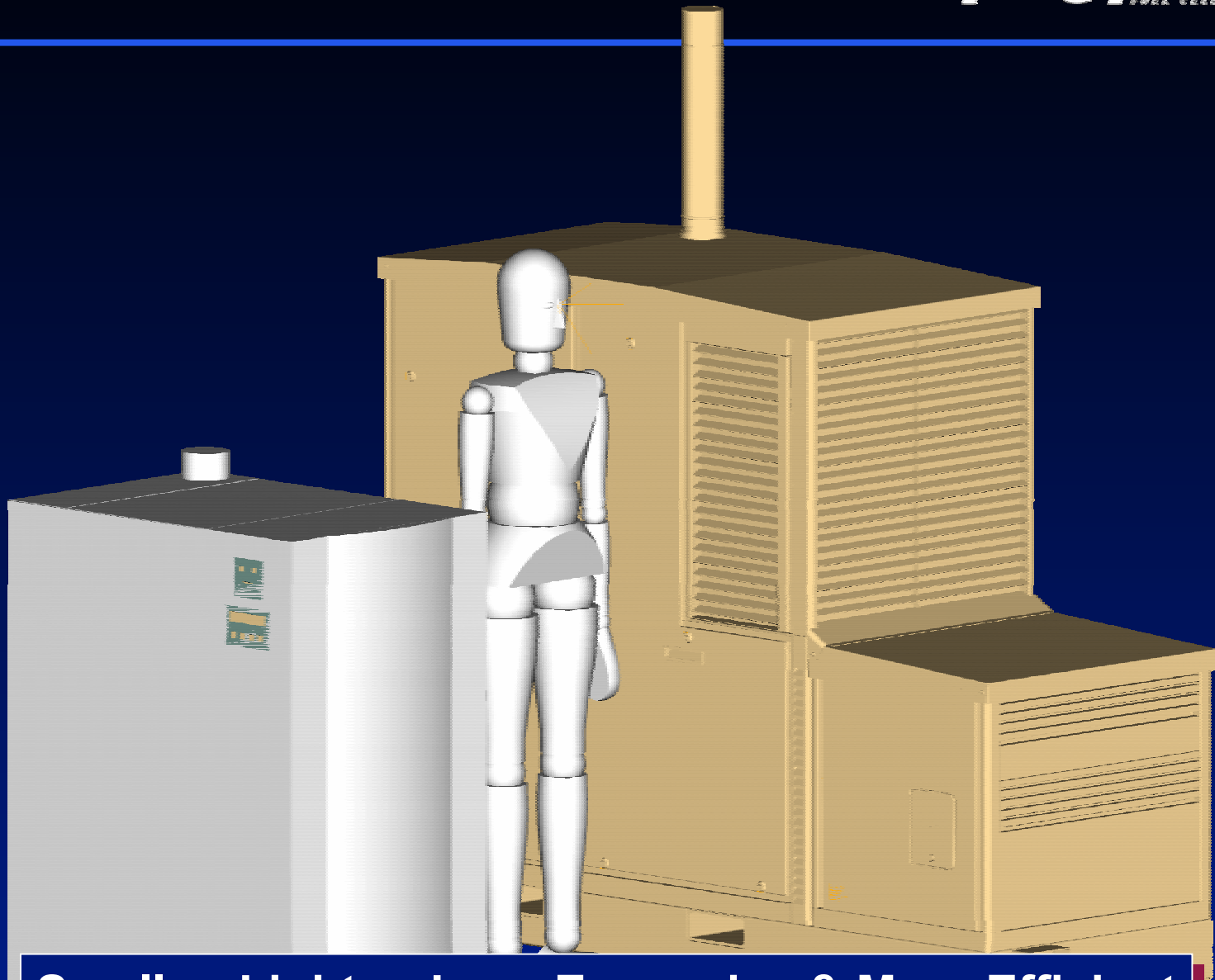
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Companies like these are feverishly working to be the first with a commercially viable solution.



# The Next Generation



**Smaller, Lighter, Less Expensive & More Efficient**

## Product Standards

- **ANSI Z21.83** - Standard on Fuel Cell Power Plants. Scope includes stationary FCS. Currently addresses natural gas and propane fueled systems.
- **ASME Performance Test Code 50** - Fuel Cell Power Systems
- **UL 1741** - UL Standard for Safety for Inverters, Converters, and Controllers for Use in Utility Interactive or Standby Systems
- **Listing and Certification** - For public safety, installations should not be allowed without field verification. Product should display compliance symbols.

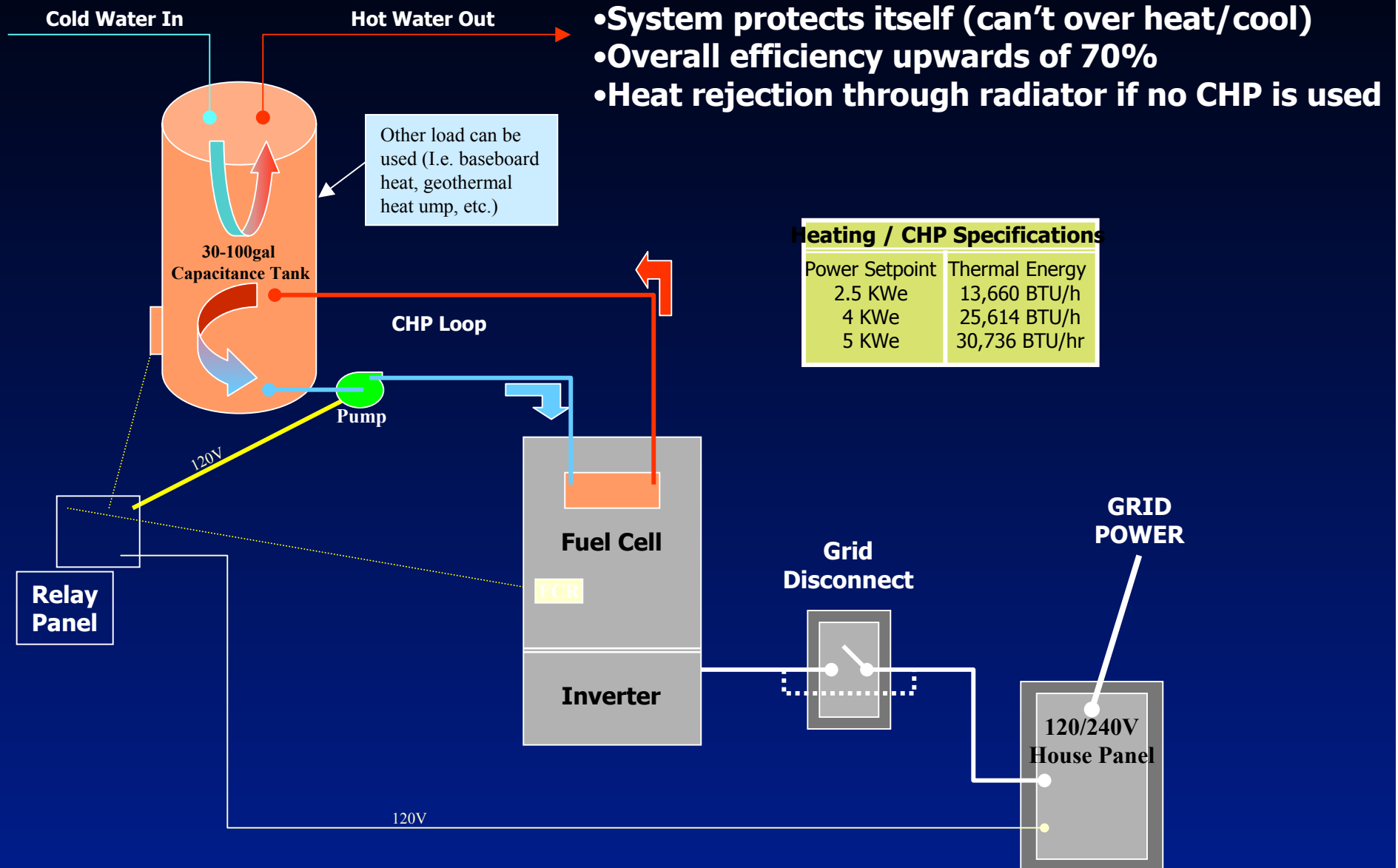


## Standards Under Development

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- **FERC** - Federal Standard for Small Generator Interconnection.
- **IEEE 1547** - Draft Standard for Interconnecting Distributed Resources with Electric Power Systems.
- **ANSI CSA FC 1** - This proposed standard will replace Z21.83 and be broadened to include most types of fuels, gas and liquid, hydrocarbons and alcohols.
- **IEC TC105** - International Fuel Cell Standard

# Installation Configuration - CHP

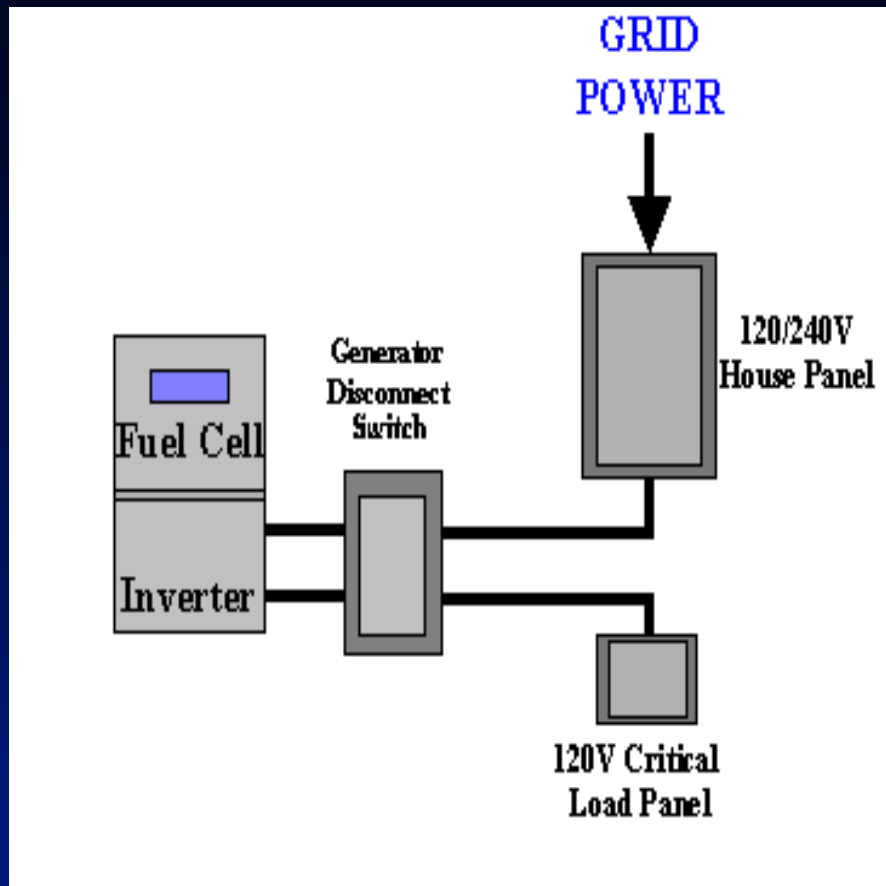


- System protects itself (can't over heat/cool)
- Overall efficiency upwards of 70%
- Heat rejection through radiator if no CHP is used

## Heating / CHP Specifications

Power Setpoint	Thermal Energy
2.5 KWe	13,660 BTU/h
4 KWe	25,614 BTU/h
5 KWe	30,736 BTU/hr

# Installation Configuration - Standby



- Inverter Technology
  - Output matches grid voltage and frequency
  - Automatic disconnect from grid when abnormal conditions exist
- Standby
  - Critical loads supplied when grid is down
  - Automatic transfer prevents interruption

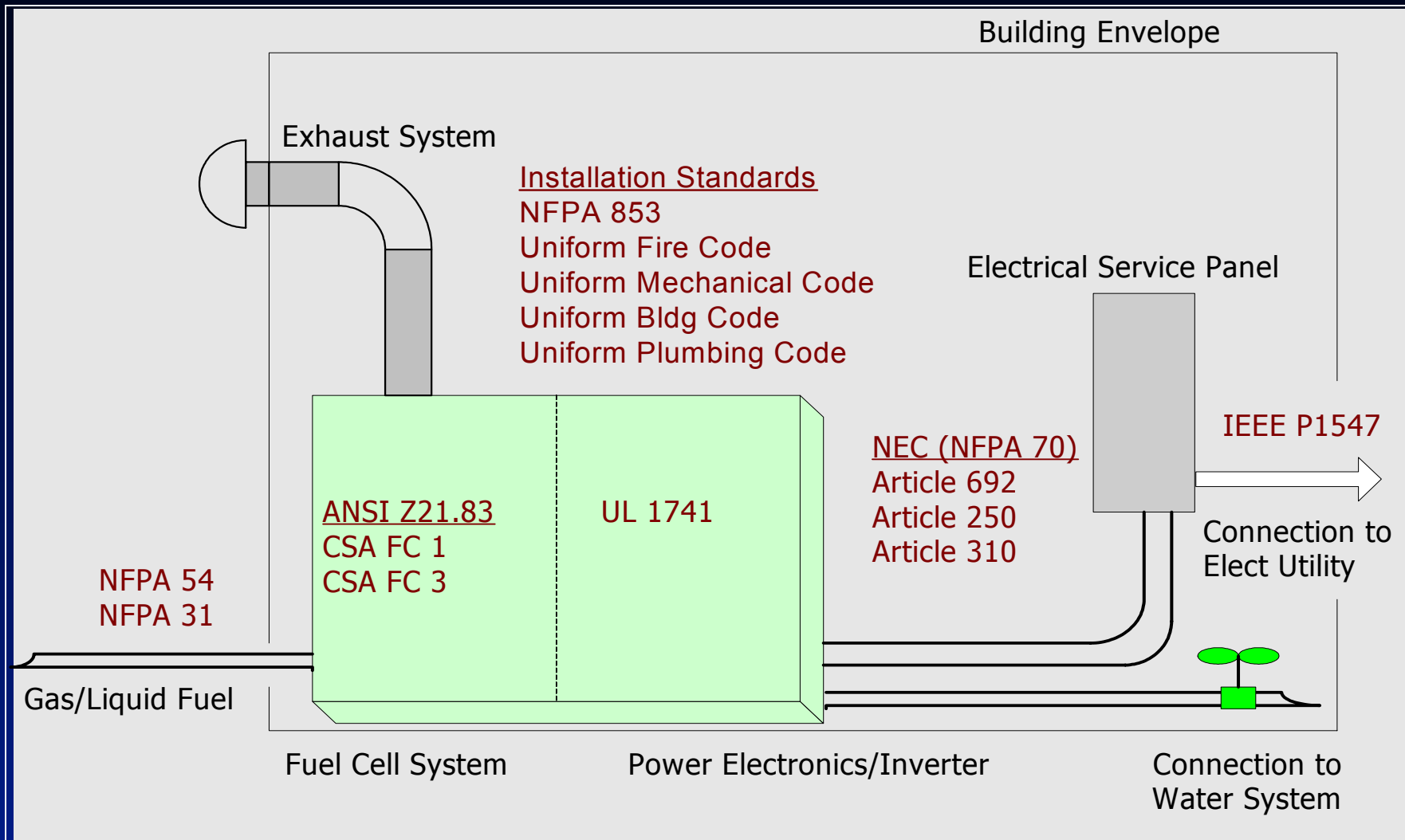
# Installation Standards

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- **Fire Safety (Fire Marshal) Considerations**
  - System Location
    - w/respect to occupied spaces
    - w/respect to windows and entry points
  - Spills and secondary containment
  - Fuel Shutoff - Interlocks
- **NFPA 31** - Installation of Oil-Burning Equipment
- **NFPA 54** - National Fuel Gas Code
- **NFPA 70** - National Electrical Code, Article 692
- **NFPA 853** - Installation of Stationary Fuel Cell Power Plants

# Installation Configuration - Interfaces - Codes and Standards



# Issues & Challenges

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- **Regulations**
  - Local regulations inconsistent
  - Unfamiliar technology brings subjectiveness
- **Permitting/Inspections**
  - Building permits
  - Air permits
  - Mechanical and Electrical inspections
  - Fire Marshall
- **Interconnection**
  - Application standardization
  - Certification process vs. individual site permitting
- **Cost**
  - Unfamiliar technology drives initial installation costs up
  - Smarter material selection (cost vs. ease of installation)
  - Standardize installations to reduce site specific customization



# Issues & Challenges - Interconnection Regulations

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- **Utility Rules**
  - Over 3500 US Utilities
- **State Public Utility Commissions**
  - California Rule 21
  - New York Standardized Interconnection Rules
  - Texas Substantive Rules Chapter 25, sections 211 & 212
  - Many others in progress
- **Pre-Certification**
  - Can significantly reduce the cost and time to interconnect with a utility.
  - Requires existing state process
  - Procedure includes UL listing and CSA certification to ANSI Z21.83



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